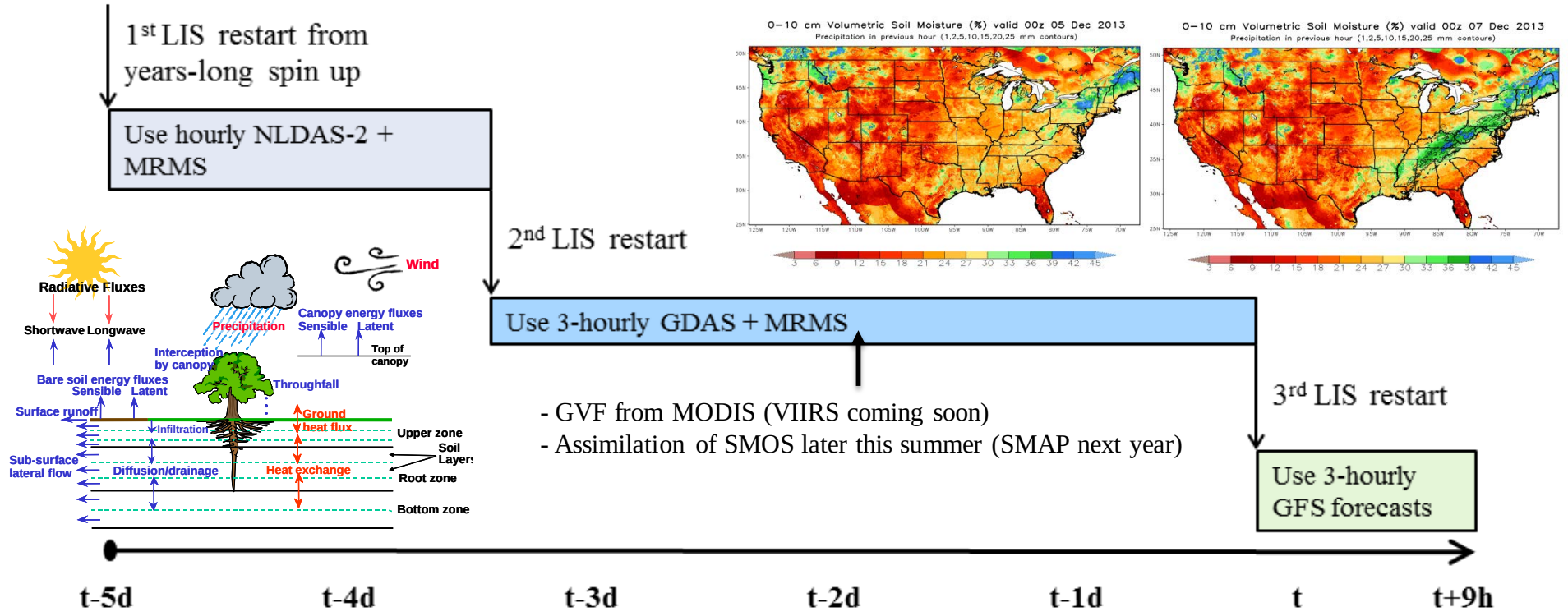
Land Surface Modeling and Data Assimilation at NASA/SPoRT for Improved Situational Awareness and Local Model Initialization

Bradley Zavodsky (NASA/MSFC)
Jonathan Case (ENSCO, Inc.)
Clay Blankenship (USRA)

Outline

- **Overview of real-time, high-resolution Short-term Prediction Research and Transition (SPoRT) Land Information System (LIS) and situational awareness applications**
- **Satellite datasets to improve LIS output for situational awareness and numerical weather prediction**
  - Green vegetation fraction (GVF) from Visible Infrared Imaging Radiometer Suite (VIIRS)
  - Soil moisture from Soil Moisture Ocean Salinity (SMOS) as a precursor for Soil Moisture Active Passive (SMAP)

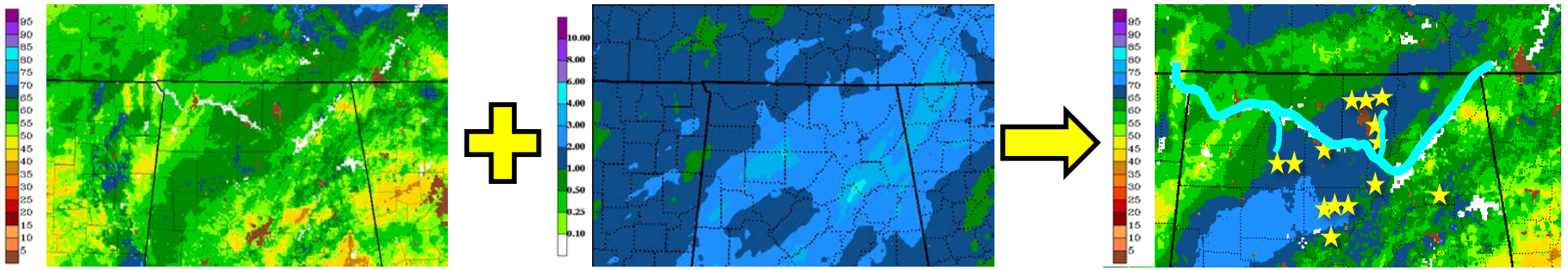
Operational SPoRT LIS



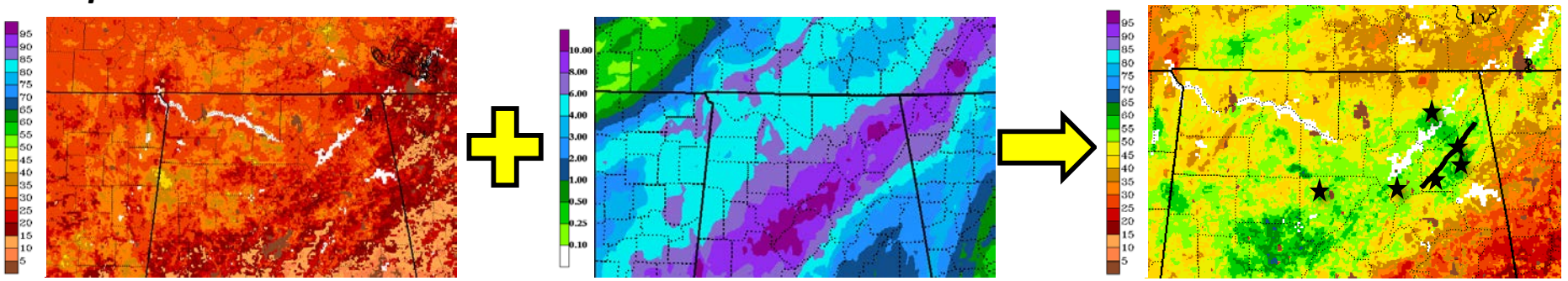
- **NASA LIS used to perform long-term integration of Noah Land Surface Model (LSM) updated in real-time**
- **Assimilation of soil moisture during 2nd LIS restart should give even more accurate LSM soil moisture fields**
- **Output used for situational awareness and local modeling by forecasters at select NWS offices and international forecasting agencies**

Application: Areal Flood Potential

March – moderate antecedent soil moisture, moderate rain

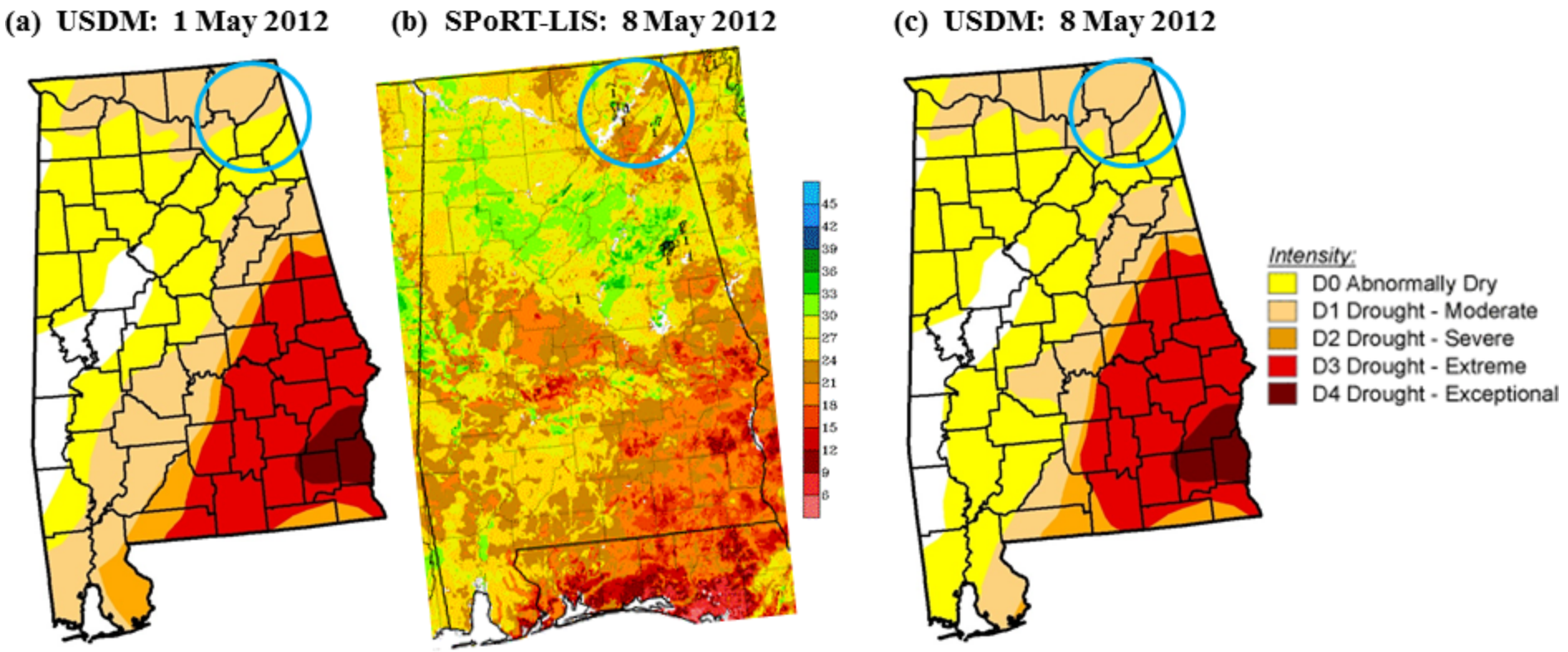


September - low antecedent soil moisture case



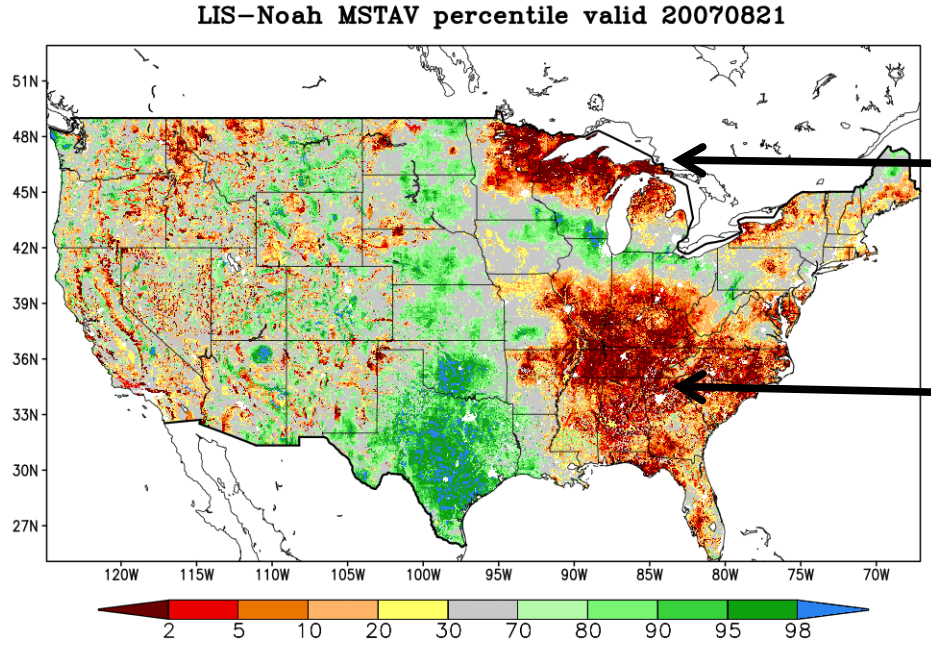
- **Contrasting antecedent soil moisture likely played a strong role in the different outcomes**
- **Analysis of several events suggests typical moderate-heavy synoptic rainfall events over deep-layer relative soil moisture values exceeding 55-60% will lead to more substantial moderate or heavier flooding events**

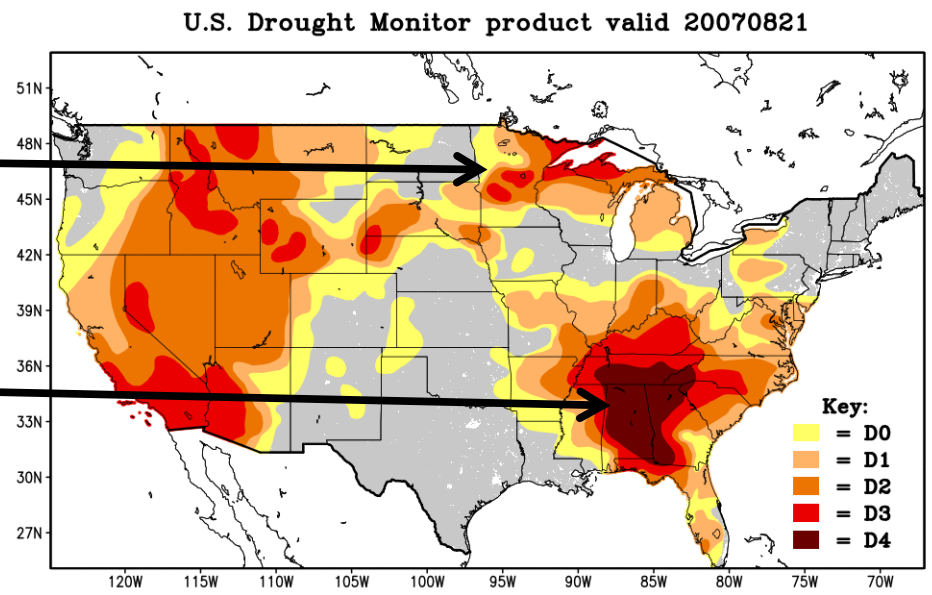
Application: Drought Monitoring

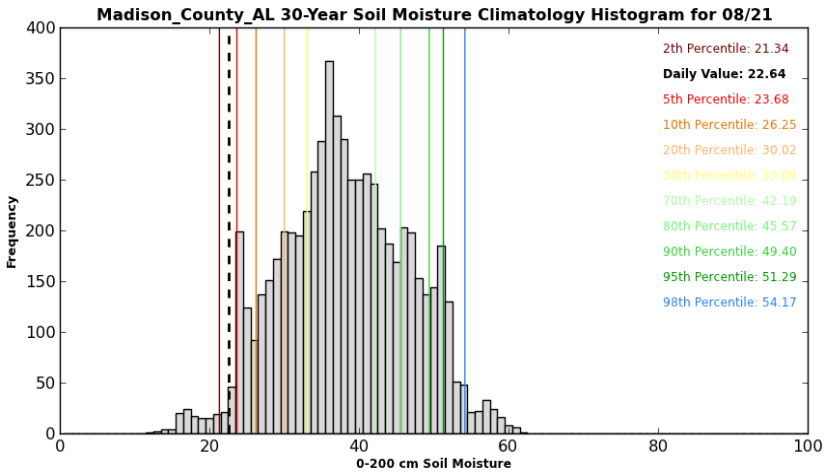


- Soil moisture from SPoRT LIS has been used by NWS forecasters to refine drought indices on the county scale
- Soil moisture and GVF output from LIS could also be applied to situational awareness and forecasts of red flag warnings and potential for fires

Application: Objective Drought Indexing







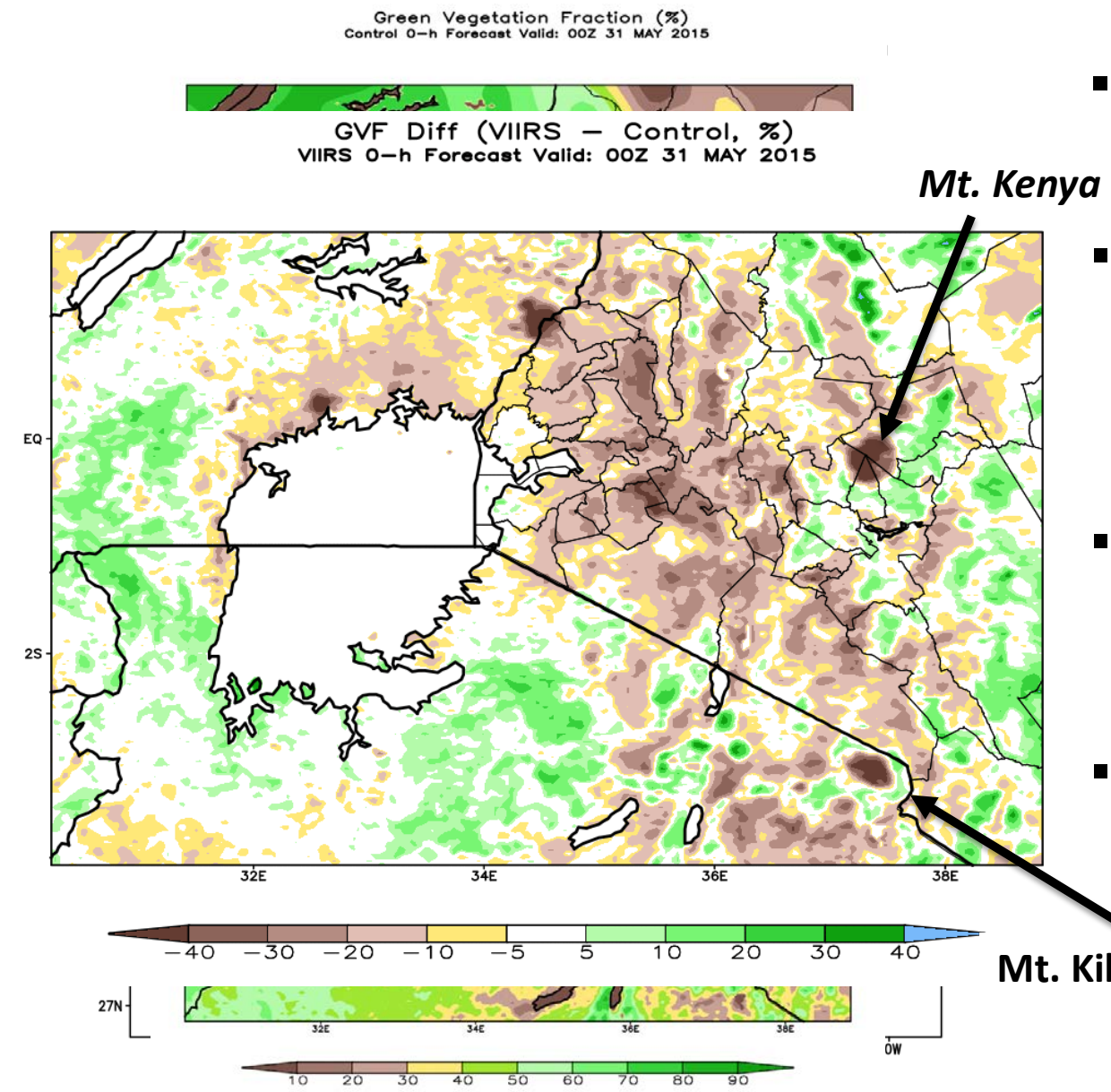
- **Proxy percentiles of USDM categories**
  - NLDAS-2 drought index in Xia et al. (2014; *JHM*)
  - Straight-up, uncalibrated 0-2 m relative soil moisture (i.e., available water)
- **Good correspondence in east**
- **Incorporating snow information over the western U.S. for better representation**

NASA SPORT

Outline

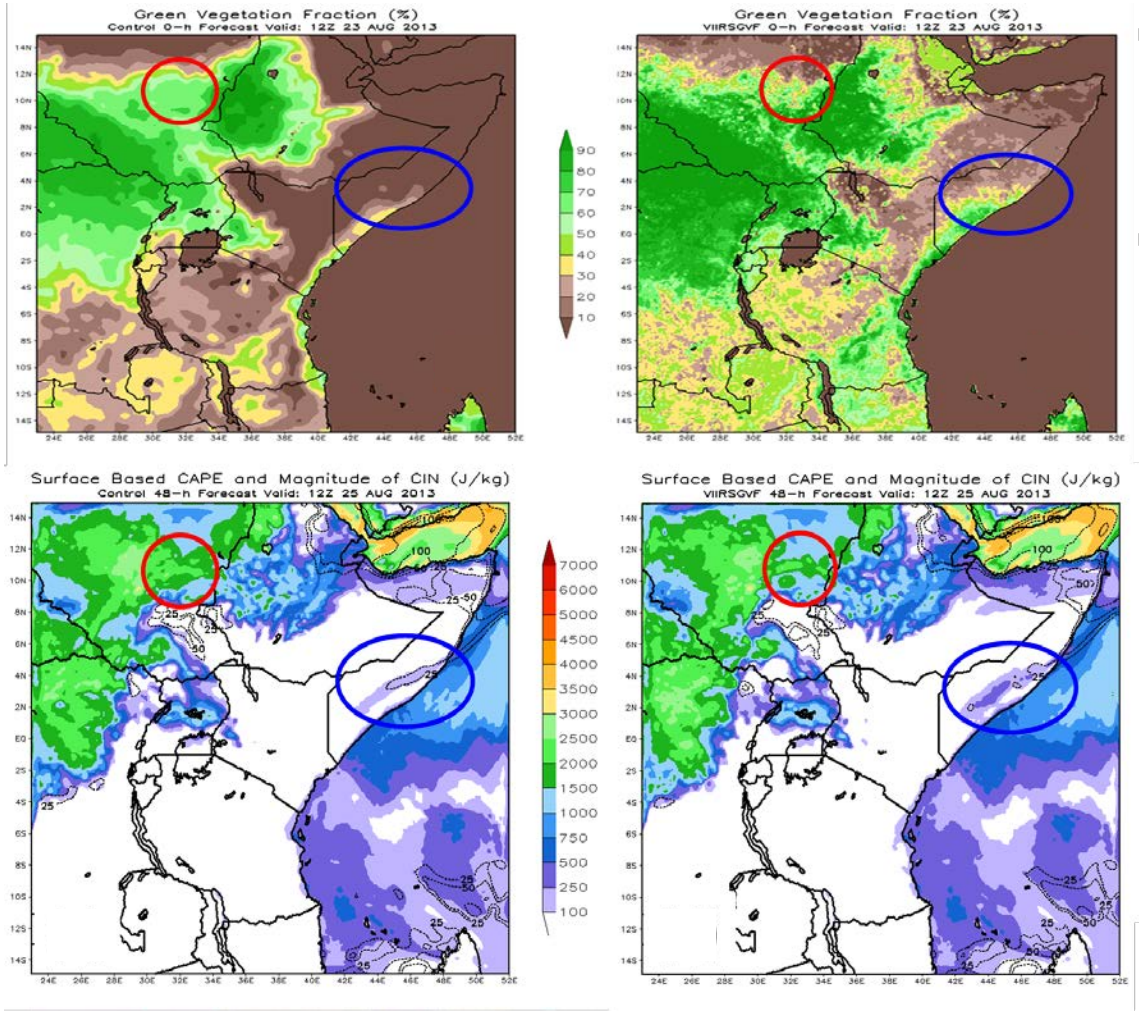
- Overview of real-time, high-resolution SPoRT Land Information System (LIS) and situational awareness applications
- **Satellite datasets to improve LIS output for situational awareness and numerical weather prediction**
  - Green vegetation fraction (GVF) from Visible Infrared Imaging Radiometer Suite (VIIRS)
  - Soil moisture from Soil Moisture Ocean Salinity (SMOS) as a precursor for Soil Moisture Active Passive (SMAP)

VIIRS GVF vs. Climatology



- NWP models use a lower-resolution climatology of vegetation
- Large differences may occur depending on weather patterns or land surface features that aren't resolved
- Differences in vegetation can lead to different representation of surface fluxes in NWP models
- Using global 4-km resolution GVF product developed by NESDIS

Model Initialization



- Hourly LIS output soil moisture provides information
- Initializing models with higher-resolution LIS data result in more accurate fields used to predict convection (figure at left)
- Convective summer storms can generate heavy rain (flash flooding)

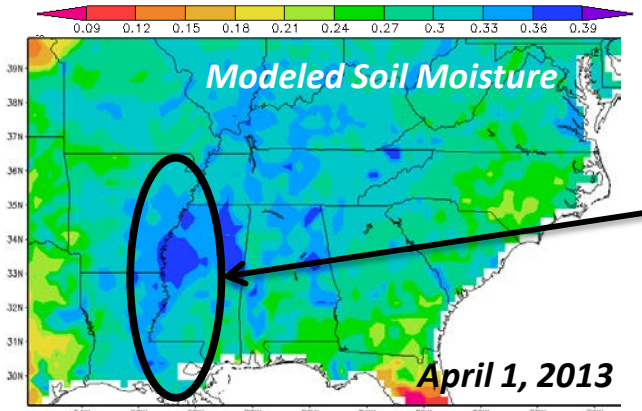
Lower GVF → Lower CAPE; Higher GVF → Higher CAPE

NASA SPORT

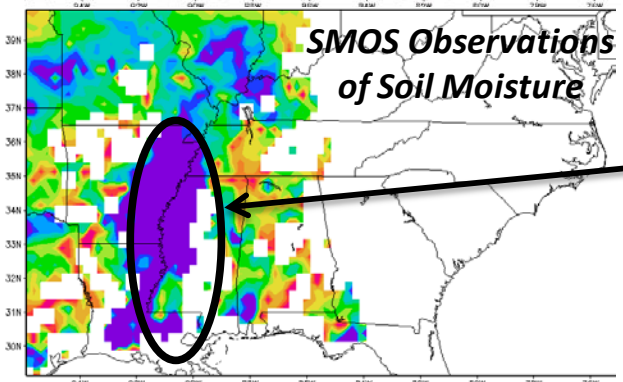
Outline

- Overview of real-time, high-resolution SPoRT Land Information System (LIS) and situational awareness applications
- **Satellite datasets to improve LIS output for situational awareness and numerical weather prediction**
  - Green vegetation fraction (GVF) from Visible Infrared Imaging Radiometer Suite (VIIRS)
  - Soil moisture from Soil Moisture Ocean Salinity (SMOS) as a precursor for Soil Moisture Active Passive (SMAP)

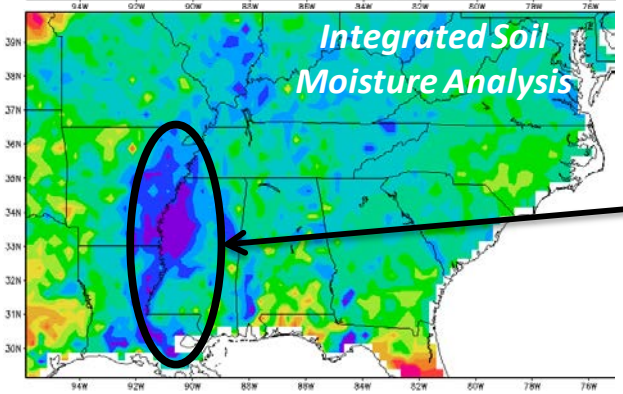
Assimilation of Soil Moisture Data



Model soil moisture concentration forced only by precipitation and misses magnitude of irrigation-saturated MS Valley

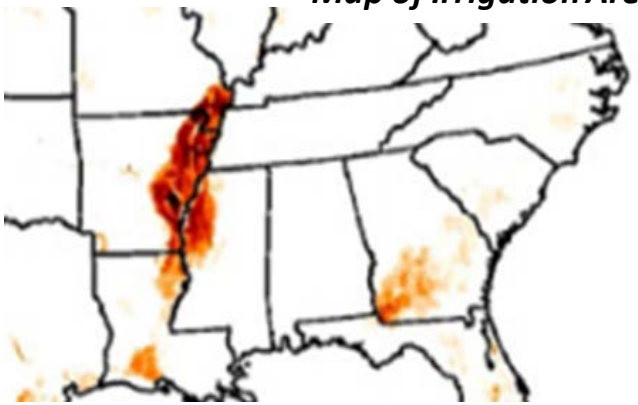


SMOS observes irrigated fields



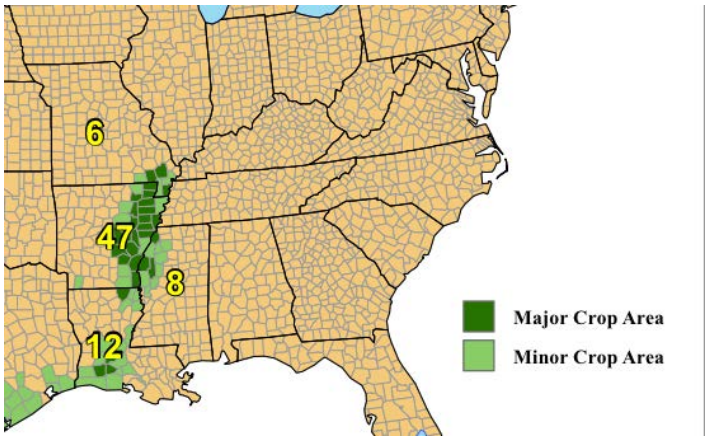
Blended analysis of model and observations better represent irrigated area and should result in improved weather and hydrologic modeling

Map of Irrigation Areas



From U. of Frankfurt-FAO (Ozdogan 2001)

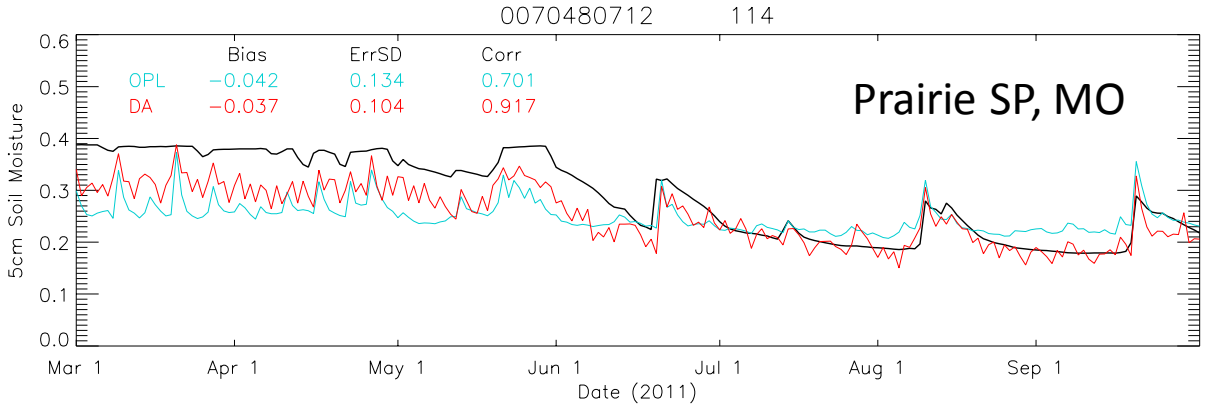
Rice growing areas

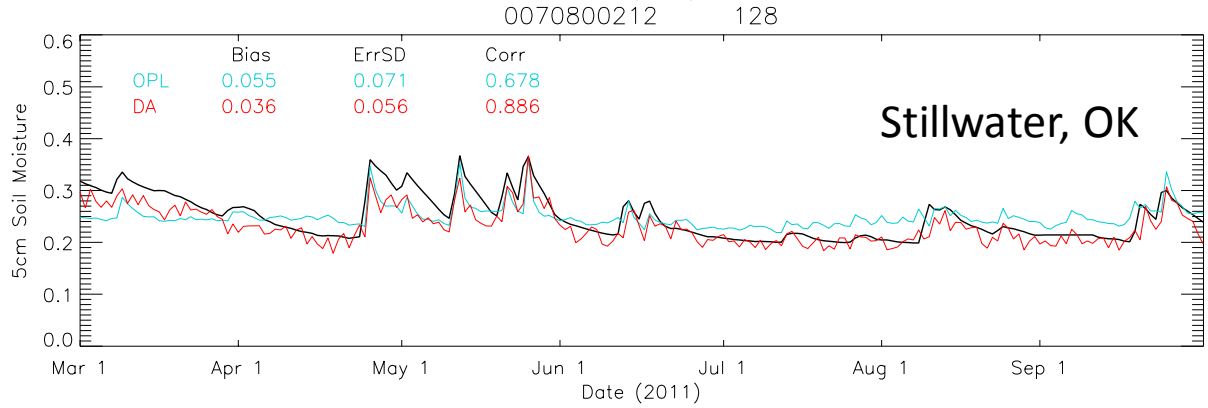


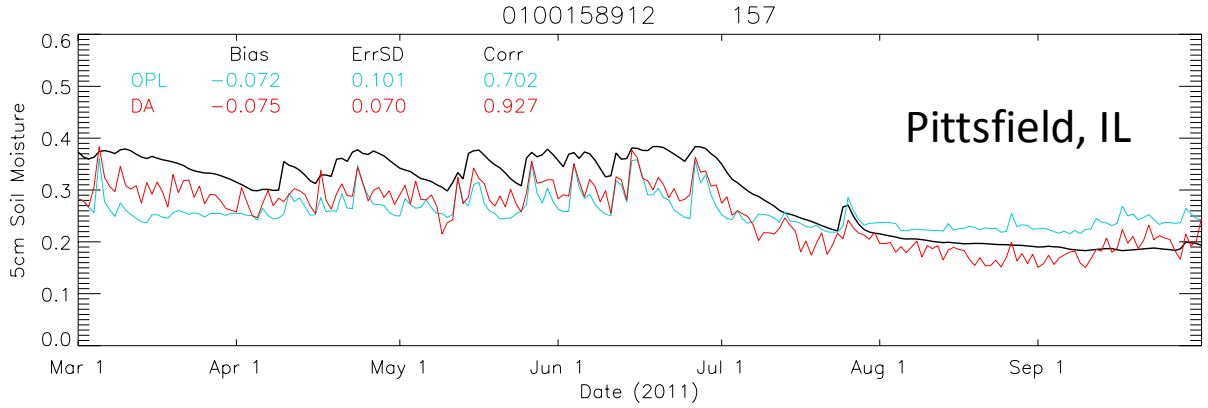
Yellow numbers indicate percentage of national crop yield due to each state.

NASA SPORT

SMOS DA Validation



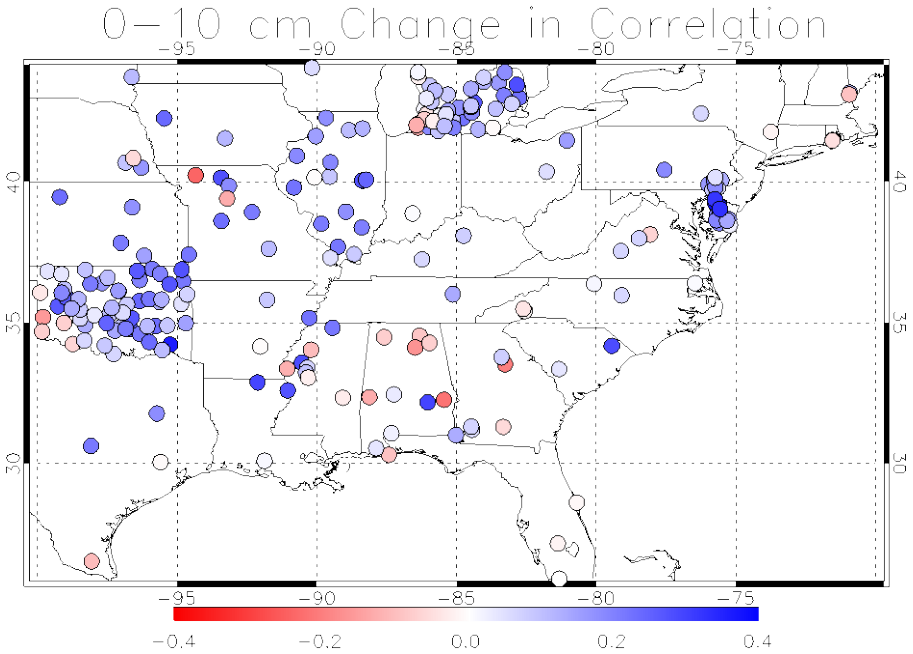


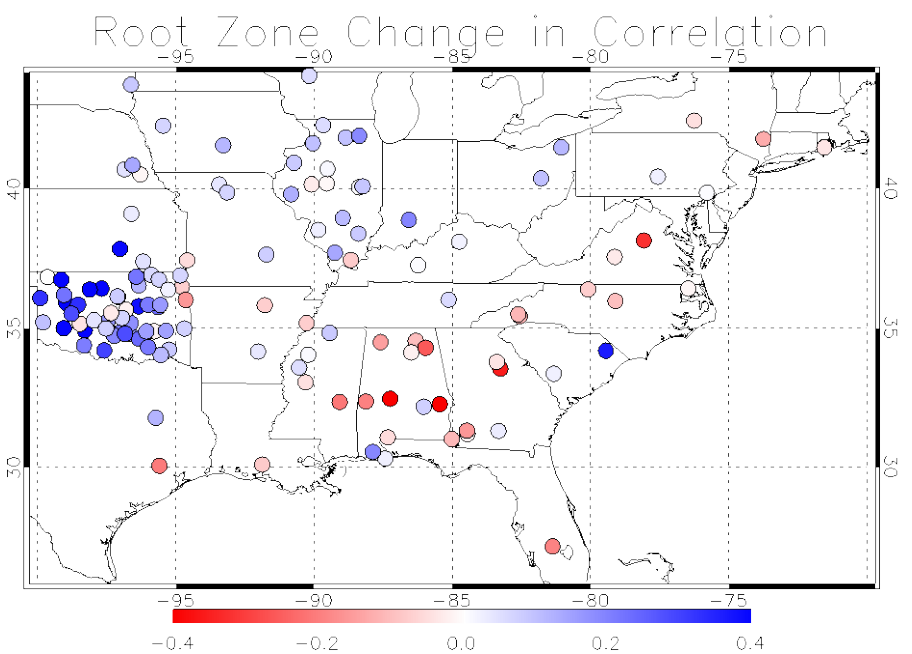


- **0-10 cm model soil moisture**
- **Results from validation against soil moisture networks in US (North American Soil Moisture Database)**
  - Better correlations
  - Improved dynamic range

NASA SPORT

SMOS DA Validation





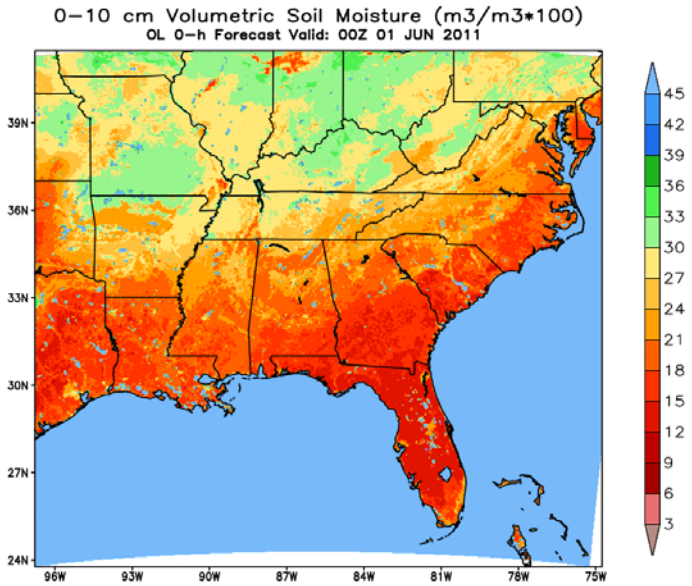
Degraded w/ DA Improved w/DA

Comparisons to ground observations for LIS runs from 1 Mar. to 30 Sept. 2011

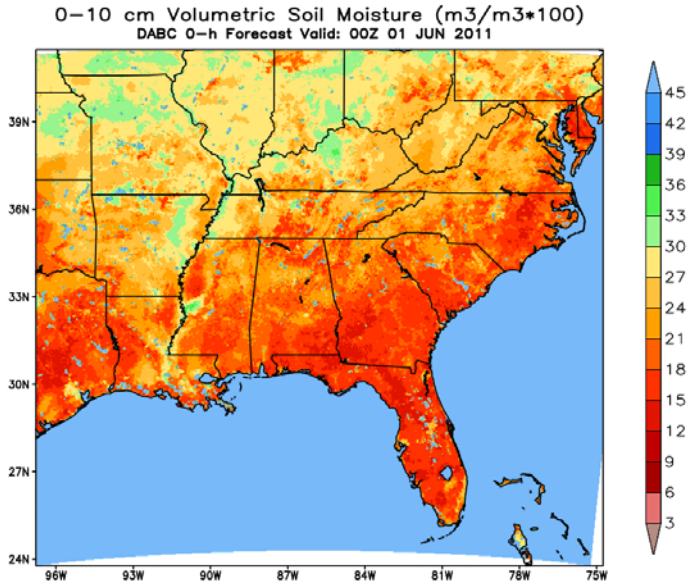
	Near Surface (0-10 cm)			**Root Zone (10-100 cm)**		
	Bias	Err SD	**Corr.**	Bias	Err SD	**Corr.**
Control	3.6%	23.5%	**0.47**	4.0%	10.6%	**0.61**
SMOS DA	-0.5%	21.8%	**0.57**	10.6%	11.8%	**0.67**

SMOS NWP Impact Study

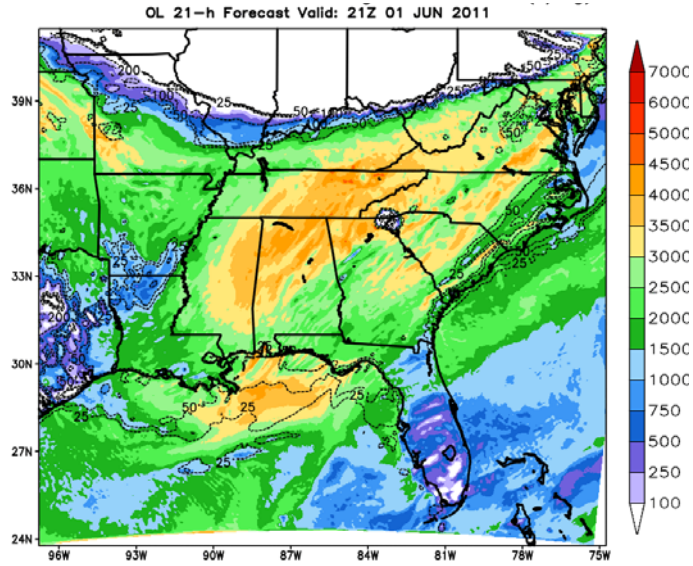
Open Loop

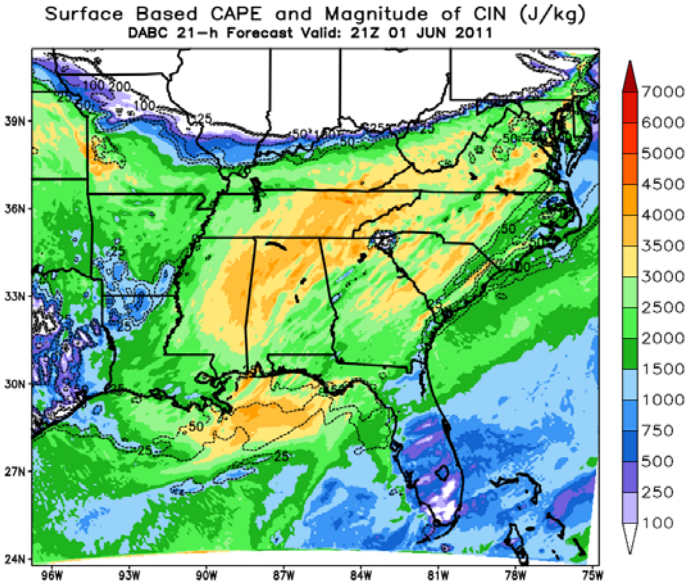


SMOS DA



Initial Soil Moisture





CAPE (48-h Fcst)

SPORT

Summary

- NASA SPoRT generates real-time, high-resolution land surface data for use as a situational awareness and model initialization tool in support of local forecasters at select NWS offices and international meteorological agencies
- Satellite observations are incorporated into this real-time system to improve over climatological fields and fill in observations gaps in data sparse regions and have been demonstrated to improve soil moisture analyses and some preliminary NWP initialization
  - Global GVF product from VIIRS
  - Retrieved soil moisture from SMOS as a precursor to use of SMAP
- Future work will focus on studying the impacts of satellite-enhanced soil moisture on regional NWP with a focus on convection